The impacts of food price and income shocks on household food security and economic well-being: Evidence from rural Bangladesh

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Abstract

This paper examines the combined impacts of food price and income shocks on household food security and economic well-being in low-income rural communities. Using longitudinal survey data of 1,800 rural households from 12 districts of Bangladesh over the period 2007–2009, we estimated a three-stage hierarchical logit model to identify the key sources of household food insecurity. The **first-difference estimator** was then employed to compare pre- and post-shock expenditure for those households that experienced acute food shortages and those that managed to avoid the worst impacts of the shocks. On the basis of our results we conclude that: (1) the soaring food prices of 2007–2009 unequivocally aggravated food insecurity in the rural areas of Bangladesh; (2) the subsequent income shocks of 2007–2009 contributed towards worsening food insecurity; (3) the adverse impacts of these shocks appeared to have faded over time due to labor and commodity market adjustments, regional economic growth, and domestic policy responses, leaving no profound impacts on households' economic well-being in most cases; and (4) although the immediate adverse consequences of rising food prices were borne disproportionately by the poor, the longer term consequences were distributed more evenly across the rich and poor and were favorable for the landless day laborers.

1. Introduction

The combined effects of food price and income shocks arising from the global food and financial crises have been claimed to be the likely causes of the sharp increase in hunger and poverty in low income countries (FAO, 2009a, 2009b). Three arguments lie at the core of this claim. First, since most households in low-income countries are net food buyers, higher food prices during 2007–2008 are likely to have reduced households' access to staple foods. Second, the global economic downturn led by the financial crisis reduced employment opportunities and remittance income through contraction in exports and foreign capital inflows (including foreign investment and development aid), thereby further limiting households' ability to purchase food at higher prices. Finally, traditional coping strategies during crises such as the selling of productive assets and indebtedness may have forced households into longer-term post-crisis destitution.

The validity of these claims and their core points of contention have not been widely tested by empirical studies. Most of the existing analyses that offer a scientific basis for these hypotheses rely on simulation approaches (e.g., Ivanic and Martin, 2008; Brinkman et al., 2010; de Hoyos and Medvedev, 2011). Generally, simulation based studies employ multi-country household survey data from the immediate pre-crisis years and assume a full rate of transmission from international to domestic scale. In some rare cases these studies take account of market and national-level responses to such shocks (e.g., adjustments to wages; incentives to export-oriented enterprises; abolition of import tariffs; food subsidies) (Ivanic and Martin, 2008; Anderson et al., 2013). The key messages of these analyses are that the poverty and food security consequences of food price and income shocks have been substantial and adverse, resulting in an additional 80 million to one billion people being classed as food insecure during 2008–2009 (USDA, 2009; FAO, 2009a).

The findings of these partial simulations require cautious interpretation. Critics argue that the core underlying assumptions (i.e., no responses to shocks) of the majority of these analyses may have resulted in an overestimation of the negative consequences. This argument has been further substantiated by recent studies examining the 'food price shock, food security and economic growth' nexus by Headey (2013) and Verpoorten et al. (2013). Headey's analysis of the Gallup World Poll data from 69 low- and middle-income countries during 2005–2008 revealed a surprising positive trend of increasing global food security: an additional 132 million people were recorded as food secure in 2008 compared to 2005–06. Likewise, Verpoorten et al. (2013) found that between 5 and 12 million people in 18 sub-Saharan African countries became more food secure over the period 2005–2008. These studies concluded that the impacts of a food price shock on food security are highly context specific. Thus, the true impact can only be known when household surveys from the affected countries are analyzed (Harttgen and Klasen, 2012).

Decades of academic research on the nexus between 'food price shock and poverty incidence' suggests that the welfare implications of high food prices are not straightforward (Sah and Stiglitz, 1987; Ravallion, 1990; Swinnen and Squicciarini, 2012). Although net food buying urban dwellers certainly do suffer, a food price shock is likely to cause winners and losers among the rural communities (Swinnen and Squicciarini, 2012). Which groups (e.g., farming or non-farming households, landowners or non-landowners) are helped or hurt depends on the rapidity and magnitude at which labor and commodity markets, both inside and outside agriculture, adjust in response to price shocks (Sah and Stiglitz, 1987; Jacoby, 2013). Using a partial equilibrium model of food price change and induced wage, Ravallion (1990) concluded that the short- and long-term welfare consequences of a food price hike vary substantially between the poor and non-poor. The rural poor are likely to lose in the

short-term, but the adverse effect is likely to cease over a period of three or four years by making the welfare of a typical poor household neutral to food price shocks.

Like the 'food price shock and poverty incidence nexus', the nexus between 'income shock and poverty incidence' is also highly context specific. Neo-classical economic theory (e.g., the permanent income hypothesis) and empirical evidence from developed countries suggests that transitory income shocks are smoothed through saving and dissaving and therefore have no negative implications for household welfare (Friedman, 1957; Kukk et al., 2012). Empirical studies from low-income countries reveal significant negative welfare consequences of transient income shocks due to credit constraints and an absence of formal insurance markets (e.g., Morduch, 1994). However, such negative consequences are unlikely to be permanent in societies with informal insurance arrangements and well-designed social safety nets (Jalan and Ravallion, 2001). Jalan and Ravallion (2001) found that both rich and poor households eventually bounce back from transient income shocks, the speed of recovery being slower for the poor than for the non-poor.

Empirical studies examining the impacts of food prices and income shocks on rural households' food security and welfare using country specific household level data are rare in the literature. There is currently only one empirical study that examined the short-term welfare impacts of the 2007–2008 food price shock using contemporary (2008) cross-sectional data from rural communities in Côte d'Ivoire (Dimova and Gbakou, 2013). Dimova and Gbakou's (2013) study was unable to capture the longer-term welfare impacts of the shock as the evaluation was undertaken at a time when the food price shock was still ongoing. Further, an analysis of the extent to which a subsequent income shock might alter the dynamics of food security and welfare impacts remained outside the scope of their study. Thus, knowledge gaps clearly exist with regard to (1) the longer-term distributional impacts

of a food price shock in rural communities; and (2) the nature and extent to which a subsequent income shock may worsen the food security and welfare impacts for poor and non-poor communities.

Given this background, this paper presents an empirical household level study of the simultaneous effects of food price and income shocks on the food security and economic well-being of low-income rural communities. Our study draws on a unique longitudinal survey dataset gathered from 1,800 rural households in 12 districts of Bangladesh over the period 2006/07–2009/10. The time span covered by our data offers an ideal opportunity to capture both the short- and long-term impacts of the food price shock observed in Bangladesh during 2007–2009 in combination with a number of idiosyncratic and covariate income shocks between 2007 and 2009. The richness of the data set allows us to estimate a three-stage hierarchical logit model which provides a bimonthly analysis of self-assessed food security by accounting for the spatiotemporal dynamics of the food price shock. In addition, the model controls for a range of observable income shocks (i.e., remittance inflows and loss and damage incurred due to negative events) and tests hypotheses related to unobservable effects through scale heterogeneity. The panel nature of the data offers the opportunity to assess longer-term welfare impacts of the crises by comparing the pre- and post-shock expenditure profiles of the sampled households. To this end, we employ a first difference estimator by controlling for fixed and time-varying household-level heterogeneity. To the best of our knowledge, such an in-depth empirical examination of the food security and welfare consequences of food price and income shocks is non-existent in the literature.

The rest of the paper is organized as follows. Section 2 discusses the key macroeconomic parameters of Bangladesh during 2006/07–2009/10, followed in Section 3 by a description of the household data used in the empirical analysis. Section 4 presents descriptive statistics for

the key variables of interest. Section 5 identifies the determinants of the self-assessed food security indicator by estimating a three-level hierarchical logit model. Section 6 discusses the objective food security indicator and analyzes the welfare impacts by comparing per-capita consumption expenditures before and after the crises. Section 7 discusses the main results and Section 8 outlines our key conclusions and policy implications.

2. The Context: Macro-economic Indicators of Bangladesh during 2006/07–2009/10

Bangladesh is one of the poorest countries of the world. Approximately 75 percent of the country's population of 160 million lives in rural areas, earning an average of US$1,300 per household per year (BBS, 2011a). Bangladesh is an agrarian country and a net importer of food. In fiscal year 2008, imports constituted 13 percent of the country's total rice and wheat supply (Bangladesh Bank, 2008). Rice is the staple food accounting for over 70 percent of the total calorie intake. Rice is also the dominant agricultural crop occupying two-thirds of the total arable land. Agriculture contributes to 20 percent of the gross domestic product and employs more than half of the total labor force (BBS, 2011b). Bangladesh is the second largest South Asian country in terms of international labor supply and the sixth largest source of global immigration (World Bank, 2011). Net exports and foreign remittances make up 20 percent of Bangladesh's gross national income (BBS, 2011b).

Figure 1(a) presents the trends of the FAO Cereal Price Index and the retail price of coarse rice in Bangladesh during January 2007–December 2009. As shown in Figure 1(a), there was a strong positive correlation between domestic rice price movement and FAO Cereal Price Index ($r=0.83$, $p<0.001$). The results of a simple linear regression analysis (Table 1) suggest that the positive association was statistically significant in most cases, except for the first quarter of 2008 when the rice price was 60 percent higher than its mean in 2007 and 2009. The price rise during this period was likely to have been triggered by two consecutive natural

hazards in the last quarter of 2007 (monsoon floods in July and September, and Cyclone Sidr in November). The impact of Cyclone Sidr was particularly pronounced as it washed away 1.3 million tons of standing Aman (the wet season rice) crop. This is equivalent to four (10) percent of the yearly (wet season) rice production in Bangladesh during a good year (BBS, 2011c). The crisis was further intensified by speculative increases in private stock holdings undertaken by consumers and traders as well as by export restrictions imposed by India, Bangladesh's main supplier of imported rice at a subsidized price, in October 2007 (Dorosh and Rashid, 2013).

INSERT FIGURE 1 HERE

INSERT TABLE 1 HERE

Nominal (daily) wages in all sectors of the economy rose significantly during 2007–2009 (Figure 1(b)). On average, nominal wages rose by 31 percent in 2008 and by 48 percent in 2009 (relative to the last quarter of 2006). The average growth in nominal (real) wages for agricultural laborers engaged in crop production activities (i.e., land preparation, sowing, planting, weeding, irrigating, harvesting, and threshing) during 2007–2009 was 41 percent (24%) as opposed to a 19 percent (4%) growth in nominal (real) wages in the non-agricultural sectors (BBS, 2011d; Zhang et al., 2013). Even after the rice price rise started to slow down and the price returned to its pre-shock level during the first quarter of 2009, nominal wages in the agricultural sector continued to grow. In 2009, nominal wage growth in the agricultural sector was 26 percent higher than the rise in the rice price which clearly turned the rice-wage terms of trade in favor of the agricultural day laborers. The prices of other food commodities also rose substantially. Soybean (a key source of fat) and lentil (a key source of protein) prices were 30 percent higher in 2008 than in 2007. The price of soybeans had returned to its 2007 level by 2009 but the lentil price showed no sign of stabilization. Fish, poultry and

livestock prices increased by 50 percent on average between fiscal year 2006 and fiscal year 2009 (BBS, 2011d).

The impacts of the global financial crisis on the Bangladesh economy were somewhat mixed. In the immediate aftermath of the crisis, i.e., in fiscal year 2009, Bangladesh's gross domestic product, export, import, foreign remittance and skilled labor migration growth all fell (Figures 2 (a) (b) (c)), while overseas development assistance and foreign direct investment grew by over 20 percent (Bangladesh Bank, 2013). Low import volumes negatively affected government revenue leading to a budget deficit of 4 percent of gross domestic product in fiscal year 2009. Lower revenue collection weakened the government's ability to finance the expansionary fiscal policies that were rolled out to insulate the domestic economy from the negative effects of the global crises. In addition to cash incentives to export-oriented small and medium sized enterprises, increased access to agricultural credit, and diesel and fertilizer subsidies, the most costly fiscal measure undertaken during the crises periods was the Public Food Distribution System which assisted 30 million poor and vulnerable people throughout the country in fiscal year 2008 (Demeke et al., 2009). These support programs faced significant financing challenges in the face of shrinking government revenues and a widening budget deficit.

INSERT FIGURE 2 HERE

3. Household Data

We used the longitudinal household income and expenditure survey data from the Chronic Poverty and Long Term Impact Study in Bangladesh, collected by the International Food Policy Research Institute (IFPRI) (IFPRI, 2012). This dataset includes 1,810 households from 12 districts across Bangladesh. The panel survey builds on two separate impact evaluation studies: (i) the introduction of new agricultural technologies in 1996/97; and (ii) the provision

of food or cash for education (FFE/CFE) in 2000. Around 1,000 households from 4 districts were interviewed for Study 1 and 600 households from 10 districts were interviewed for Study 2. The household and village samples were not selected to be strictly representative of rural Bangladesh although the sample is reasonably large and covers a significant portion of the country (Appendix A). In 2006/07, the samples of studies 1 and 2 were linked through a joint follow-up survey that targeted all baseline households (excluding 2 districts of Study 2) as well as local split-off households. An additional follow-up of the 2006/07 surveys was conducted in 2009/10 using the same approach. These two survey rounds (i.e., 2006/07 and 2009/10) were used in the present study by constructing a longitudinal data set in which the 2006/07 survey round served as the baseline. The attrition rate for the 2009/10 survey round was 4 percent (n=71). Households headed by a female or a relatively younger individual (<40 years) were slightly more likely to drop out (female head: Chi square=5, $p<0.05$; age: Z=5, $p<0.05$). The attrition rate showed no significant difference across per capita household expenditure, head of household's primary occupation or number of household members employed in the agriculture versus non-agricultural sector.

In addition to standard modules on food and non-food expenditure, land and non-land assets, income, employment, remittance flows, out-migration, and negative and positive shocks, the 2009/10 survey questionnaire included a module on self-assessed food security (Appendix B). This type of subjective-qualitative technique is commonly used in combination with standard objective-quantitative indicators such as anthropometry, food consumption, income, and wealth. Such practices aim to capture the multi-faceted nature of the food security concept—availability (i.e., adequate food supply), access (i.e., monetary and non-monetary resource), utilization (i.e., non-food inputs such as clean water, sanitation, and health care), and vulnerability (i.e., the risk of losing access to food in the future) (FAO, 2003).

A considerable debate persists about the superiority of qualitative versus quantitative measures in the face of their weak empirical correlation (Migotto et al., 2006). Research has shown, for example, that subjective indicators are susceptible to overestimation bias (Devereux, 2003; Heady, 2013). In particular, the simple and widely used consumption adequacy questions (i.e., 'Concerning your family's food consumption over the past one month, which of the following is true? (i) Less than adequate; (ii) Just adequate; (iii) More than adequate), were found to depend on a household's position in the society relative to others and the respondent's perception of the household's changing status over time. Proponents of subjective indicators claim that the biases can be eliminated by using sophisticated context-specific modules that are developed through in-depth research and extensive field testing (Migotto et al., 2006; USDA, 2005).

In light of these concerns, the subjective food security module used in the IFPRI 2009/10 survey clearly goes beyond the simple consumption adequacy format. The first five questions of the module identify the month and year of the worst food shortage incidence during 2007–2009. Food shortage is characterized by an event triggered by the absence of both food and financial reserves. Once the timing of the worst episode is identified, a set of follow-up questions were asked about the quality and quantity of foods consumed during the worst episod to gather some objective perspective of the event.

In addition to the self-assessed indicators, the dataset includes a range of quantitative indicators that are commonly used as measures of objective food security (or accessibility), such as income and expenditures (Migotto et al., 2006). These indicators are also frequently used as measures of economic well-being (or welfare) (Meyer and Sullivan, 2003). For both food accessibility and welfare measures, expenditure is preferred over income since it is less vulnerable to under-reporting bias and temporary fluctuations due to transitory events (Meyer

and Sullivan, 2003). Further, expenditure can be divided into food and non-food items and therefore, provides a clearer picture of food accessibility than income.

4. Descriptive Statistics of the Key Indicators

4.1. Self-assessed Food Security

Almost half (45%) of the 1,810 households interviewed during the 2009/10 survey stated that they experienced food shortages at least once during 2007–2009. Almost two-thirds (63%) of the worst food crisis incidents occurred in 2008. This number is consistent with the FAO estimate of 64 million food insecure people (43% of the total population) in Bangladesh in 2008 (FAO, 2009b). The distribution of the stated food shortage incidences across years and months shows a clear pattern of seasonality around March–April and September–October (Figure 3). This pattern closely corresponds with the agricultural lean periods characterized by phases of fewer wage earning opportunities in rural areas. Seasonal unemployment can be more acute during the dry season lean period (i.e., March–April) than the wet season lean period (i.e., September–October) depending on the availability and cost of irrigation in different parts of the country.

INSERT FIGURE 3 HERE

Over half (54%) of the households that experienced a food shortage in 2008 cut back at least one meal daily as opposed to 41 and 45 percent of those experiencing a food shortage in 2007 and 2009 respectively (Chi square=55, $p<0.001$). The average and median number of meals skipped per household was also the highest in 2008 (2007=0.77 & 0; 2008=1.41 & 1; 2009=1.20 & 0). Over half (58%) of the households that were food insecure in 2008 consumed less preferred food all the time or often, as opposed to 40 and 46 percent of food insecure households in 2007 and 2009 respectively (Chi square=15, $p<0.001$). Finally, over a

third (38%) of food insecure households in 2008 reduced both quality and quantity of food as opposed to 22 and 30 percent of food insecure households in 2007 and 2009 respectively. These statistics imply that the extent as well as the nature of the food crisis in 2008 was significantly more severe than that in 2007 or 2009.

4.2. Coping Measures

Households were asked about the measures they used to cope with the food price shock of 2008. Expenditure adjustment was the most commonly adopted coping measure stated by the respondents (78% of cases) followed by changing labor supply decisions (47% cases), i.e., working extra hours. An additional household member (who was not working before the crisis) joined the labor force in 10 (for female) and 20 (for male) percent of cases. Over two-thirds (69%) of the affected households borrowed money from microfinance institutions, local money lenders, and friends and relatives. Forty percent households depleted their savings and around a quintile sold assets. Over a quarter (28%) of the affected households received help from the government and the local community during the crisis. Less than a third (28%) of the affected households bought food from government-operated subsidized outlets. The most commonly stated reasons for not accessing subsidized outlets were that the outlet was too far (25%) and that there was a long queue (25%).

4.3. Remittance, Transfer Income and Negative Events: 2007–2009

Inflows of remittances (cash and in-kind) increased during 2007–2009 both in terms of the number of recipient households and their size. However, the growth rate was lower in 2009 compared to 2008. The proportion of households receiving remittances increased from 14 percent in 2007 to 18 percent in 2008 and 21 percent in 2009. The average remittance size increased from Tk. 62,000 (US$895) in 2007 to 66,000 (US$964) in 2008 and 2009. While a majority of the recipients received remittances from domestic migrants, the proportion of

households receiving foreign remittances grew from 37 percent (5% of the sample) in 2007 to 42 (7.5% of the sample) percent in 2008 and 46 percent (10% of the sample) in 2009. The proportion of households receiving cash or in-kind support from government operated social safety net programs (i.e., Vulnerable Group Development, Vulnerable Group Feeding and Food for Work) declined by 10 percent (from 20% to 10% of the sample) while the average size of income from these programs remained fairly stable (from Tk. 1215 (US$18) per household in 2006/07 to Tk. 1126 (US$16) in 2009/10).

Between 10 and 15 percent of the sampled households experienced negative shocks each year. The most commonly experienced negative shock was unforeseen medical expenses (22% cases) followed by loss of crop, livestock and other productive assets due to flood, drought and storm surges (15% cases) and dowry payment and wedding related costs (9% cases). The other not so commonly experienced shocks were income loss due to illness or injury (3% cases), court cases (4%) and bankruptcy (2%). The mean and median loss and damage costs per household per year were US$200 and US$72 respectively. This was 12(5) percent of the mean (median) yearly household consumption expenditures.

5. Explaining Variations of Self-assessed Food Security

In this section we identify the determinants of the stated responses of food shortages by testing the correlation with observed food prices, income shocks, and other relevant explanatory variables. Our dependent variable is the response to the question relating to the year and month of the worst food shortage episode (see Question#5 in Appendix B). In the next sub-section we discuss the econometric model used to analyze the data followed by the estimation results in the succeeding sub-section.

5.1. The Econometric Model

The self-assessed food security question (#Q5) can be viewed as a multilayered nested choice problem (Figure 4). The top level of the nest (Level 3) offers two choices as to whether food shortages were experienced during 2007–2009: *i=1(Yes), 2(No).* The second level (Level 2) offers three choices to those who chose *i=1 (Yes)* in Level 3 to indicate the year of the worst shortage, i.e., *j= 1 (2007), 2 (2008), 3(2009)*. The month of the worst food shortage is then selected in the final stage (Level 1). In our bimonthly setting, this level offers six choices: *k= 1 (Jan–Feb),……,6 (Nov–Dec).* In total, each respondent had 19 alternatives to choose from. The probability of selecting one of the 19 alternatives can be estimated by modeling this problem in a discrete choice framework. A hierarchical or nested logit model—an extended form of the widely used multinomial logit model—is the most suitable technique to analyze such multilayered discrete choices. The advantage of the nested logit model over the simple multinomial logit model is its ability to allow (or test) for the possibility that the standard deviations of the unobserved error components are different across groups of alternatives in the choice set (Hensher et al., 2005). The need for such a test or provision arises because the determinants of the choice of an alternative may not be fully captured by the observable components of the choice function. This situation is particularly relevant for our choice model because of the prevalence of the likely second order effects of the food price and income shocks.

INSERT FIGURE 4 HERE

The three-level nested logit model can be decomposed into three separate, yet linked, multinomial logit models through Equation (1):

$$P_{(k,j,i)} = P_{k|j(i)} \,.\, P_{j|i} \,.\, P_i \qquad (1)$$

The probability of experiencing food shortages in general (i.e., P_i) is modeled by the binary logit model. The second multinomial logit model captures the conditional probability of

experiencing a food shortage during a particular year $P_{j|i}$: 2007, 2008, or 2009. The conditional probability of the bimonth of the worst food shortage, i.e., $P_{k|j(i)}$, is the third multinomial logit model.

The underlying structural model encompassing the discrete choice behavior is called the random utility maximization model. Due to unobservable effects, utility (choice function in our case) is partitioned into an observable (V) and an unobservable part (ε) (for each alternative (k). Thus:

$$U_k = V_k + \varepsilon_k \quad (2)$$

Alternative 1 is chosen over alternative 2 if and only if:

$$U_1 > U_2 \quad (3)$$

Thus:

$$P(U_1) > P(U_2) \quad (4)$$

In a multilayered choice problem, it is assumed that the elemental alternatives (k) influence the choice of the composite alternatives, i.e., j and i. A nested logit model links the layers of the elemental and composite alternatives by an index known as the inclusive value. Inclusive value is equal to the log of the denominator of the multinomial model associated with the elemental alternatives. That is:

$$IV_j = log\ \{ exp(V_{Jan–Feb|j} + \ldots\ldots + V_{Nov–Dec|j})\} \quad (5)$$

This IV index is included in the choice function of the relevant composite alternative as an additional explanatory variable such that:

$$U_j = V_j + IV_j + \varepsilon_j \quad (6)$$

The parameter estimate of the IV index is the ratio of the scale parameters (λ) of the composite to the elemental alternatives (Hensher et al., 2005). The scale parameter is measured as $\lambda = \sqrt{\frac{\pi^2}{6\sigma_\varepsilon^2}}$ where pi-squared (π^2) is a constant and σ_ε is the standard deviation of

the unobserved effects (ε). In the multinomial logit model all the standard deviations (hence the scales) are constant (λ=1.283 for each alternative) and identically distributed. A nested logit model allows the scale parameter to vary thus allowing for the possibility of differences (or similarities) in the unobserved effects across groups of alternatives within a nest (Hensher et al., 2005). If the parameter estimate of *IV* (i.e., λ_j) is equal to 1, then the variances at Levels 1 and 2 are equal. This means greater independence and less correlation among the alternatives for unobserved reasons.

5.2. Results

The longitudinal household data was combined with spatially disaggregated monthly retail rice price data observed in 2007–2009. The spatially segregated nature of the rice price data controls for the spatial heterogeneity of the shock arising from local crop failure, while the bimonthly price controls for its temporal dynamics. As expected, monthly rice prices varied across districts. In particular, the mean and median prices of rice in the two districts (Barishal and Manikganj) that were hardly hit by the cyclone and riverine flooding of 2007, were significantly higher than the rest of the districts included in the study (Mann-Whitney U=2.80, p<0.01).

Table 2 presents full information maximum likelihood estimates of a three-level degenerate nested logit model (Model 1) as described in Figure 4. We also present the multinomial logit model results (Model 2) for comparison. The results were obtained using the NLOGIT Version 5 package. The first segment of Table 1 presents the results of the following choice function:

$$U_k = \beta_1 Price_k + \beta_2 Price_k{*}Occupation + \beta_3 Lean\ 1_k + \beta_4 Lean\ 2_k + \varepsilon_k \quad (7)$$

Where β_s are the coefficients to be estimated. As expected, there was a significant positive relationship between rice price and the likelihood of selecting a bimonth in both Models 1

and 2, implying that higher rice price was a significant determinant of the stated food shortage regardless of the choice of econometric approach. The estimated coefficients of both *Lean 1* and *2* (representing dry and wet season lean periods respectively) in Model 1 were positive and significantly different than zero implying that, all else equal, the likelihood of experiencing a food shortage is significantly higher during these two phases compared to other times of the year. The coefficient of *Lean 1* is also significantly higher (Z=33, $p<0.001$) than the coefficient of *Lean 2* which implies that households are significantly more vulnerable to food shortages during the dry season than the wet season lean period.

INSERT TABLE 2 HERE

The price and occupational dummy interaction variables explore how different occupational groups were affected by the rice price hike. The estimated coefficients in both Models 1 and 2 reveal that self-employed crop farmers and fish, poultry and livestock farmers were significantly less likely to feel food insecure with an increase in rice price. The signs of the estimated coefficients of agricultural labor dummy and rice price interaction are contradictory in Models 1 and 2. The nested (multinomial) logit model shows that the agricultural day laborers were significantly less (more) likely to assess themselves food insecure with an increase in rice price. The nested logit model also estimates a significant negative coefficient for the interaction between rice price and share cropper dummy and a significant positive coefficient for the interaction between rice price and salaried individual dummy while these coefficients are not statistically different than zero in the multinomial logit model.

The second segment of Table 2 presents the factors that contributed to the choices of years. Annual remittance flows, 'loss & damage' experienced due to negative shocks and unexpected positive events were the key independent variables for this segment of the model:

$$U_j = \gamma_1 \, Ln\,(Rem)_j + \gamma_2 \, Ln\,(Loss\&Dam)_j + \gamma_3 \, Positive_j + \gamma_4 \, IV_j + \varepsilon_j \qquad (8)$$

Where γs are the coefficients to be estimated. γ_4 is the scale parameter which is equal to $\frac{\lambda_{j|k}}{\lambda_k}$

where λ_k is set to 1 for all elemental alternatives irrespective of their location in a specific composite alternative (RU1 normalization). The coefficients of remittance of all years are negative in both Models 1 and 2 implying that a higher remittance income during a particular year decreased the likelihood of experiencing starvation during that year. All the coefficients of remittance variables are significant at the one percent level in Model 2 while only the coefficient of Rem 2008 is significant at the ten percent level in Model 1. The coefficients of loss & damage were significant positive determinants of choice for years in Model 1 implying a higher loss and damage in years 2008 and 2009 significantly increased the likelihood of experiencing starvation in those years. The coefficients of positive event dummies were not significant determinants of choice for years in Model 1 but the coefficients of 2007 and 2009 dummies are significant and have expected negative sign in Model 2.

The final segment of Table 2 presents the determinants of household specific characteristics (at the baseline) of the choice of food shortage (=1) versus no food shortage (=0) by estimating the following equation:

$$U_i = \delta_1 Asset_i + \delta_2 Expenditure_i + \delta_3 Ag\ Land_i + \delta_4 Net\ Buyer_i + \delta_5 Female\ HH_i + \delta_6 Religion_i + \delta_7 Divisions_i + \delta_8 IV_i + \varepsilon_i \quad (9)$$

Where δs are the coefficients to be estimated and $\delta_8 = \frac{\lambda_i}{\lambda_j / \lambda_k}$ is the scale parameter at Level 3.

The coefficients of per-capita (non-land) asset, expenditure, and cultivable land are negative and significant at the one percent level in Model 1. This suggests that poorer (assetless and landless) households were significantly more likely to assess themselves as food insecure than the non-poor (asset and land owners) households. The coefficient of *Net Buyer* (i.e., the proportion of rice purchased from the market relative to home grown production) is

significant and positive implying that lower food self-sufficiency increased the likelihood of being assessed as food insecure. *Divisions 1, 2* and *3* are dummy variables representing the three coastal divisions of the country (Khulna, Chittagong, and Barishal). These variables capture unobserved inter-regional heterogeneities (e.g., climate variability, level of government intervention, labor market efficiency, economic opportunities, and infrastructure) that may affect food security. The mean value of these coefficients are significant and negative implying that households living in the coastal divisions were significantly less likely to assess themselves as food insecure compared to the inland inhabitants (Dhaka and Rajshahi).

λ_{2007}, λ_{2008}, λ_{2009} are the scale (or *IV*) parameters at Level 2. They are all statistically different than zero at the ten percent level but not significantly different than 1. This means that the choices among the elemental alternatives (i.e., the bimonths) in each nest (i.e., 2007, 2008, 2009) are completely independent of each other. The scale parameter at Level 3 is also significantly different than zero but not significantly different than one. Although this implies that a multinomial logit model would be as efficient as a nested logit model, the nested logit model appears to be superior than the multinomial logit model with regards to model fit statistics (i.e., Log Likelihood values, Pseudo R-squared, and AIC). Further, the signs of some of the MNL estimated coefficients for the Levels 2 and 1 variables (*Lean 2, Loss & Dam 2007, Loss & Dam 2009*) are not theoretically consistent. This means that the nested logit model is also superior in terms of construct validity, i.e., the extent to which economic theory explains the variations in empirical behavior or choice.

The percentage change in the probability of experiencing a food shortage when the price of rice increases by one percent (i.e., rice price elasticity of food shortage) is presented in Appendix C. The elasticities estimated from both models are positive and greater than 1. This

means that self-assessed food insecurity is food price elastic. In other words, if all other factors remain constant, a one percent rise in rice price invokes a more than one percent rise in the likelihood of experiencing food insecurity in the rural areas of Bangladesh.

6. Welfare Consequences of Food Price and Income Shocks

The simplest way to assess welfare impacts is to compare the welfare outcome before (2007) and after (2010) between the affected and non-affected households using a first difference estimator. Our key welfare outcome is household expenditure which is the sum of food and non-food expenditures. These expenditures were adjusted for food and non-food inflation using the food and non-food consumer price index (CPI) for rural areas (Appendix D) (BBS, 2011d). The expenditure data were further used to estimate head count poverty rates following the poverty line expenditure data released by the Bangladesh Bureau of Statistics (BBS, 2011a).

6.1. Pre- and Post-shock Food and Non-food Expenditures

Figure 5 presents the (kernel density) distributions pre- and post-shock per-capita and per-adult (15+) equivalent expenditure. The average per-adult equivalent expenditure of the overall sample significantly decreased in real terms in 2010. The decrease was dominated by a significant decline in food expenditure and an insignificant decline in non-food expenditure (Appendix E). Disaggregating these changes across four mutually exclusive groups reveals a similar trend in all cases, i.e., a significant decrease in the food expenditure and no significant change in the non-food related expenses. The head count (upper) poverty rate increased significantly in the overall sample from 6 percent in 2007 to 21 percent in 2010 (Chi square=39, $p<0.001$) (Table 3). The highest increase in the poverty rate (20.6%) was in the group that experienced food shortage in 2007. However, the differences in poverty growth

between food secure and insecure groups were not significantly different at the ten percent level.

INSERT FIGURE 5 HERE

INSERT TABLE 3 HERE

6.2. Determinants of Expenditure Growth

We define $lnE_{t+1,t}$ as the natural logarithm of per-capita expenditure in period t (i.e., 2007) and $t+1$ (i.e., 2010). The first difference specification for expenditure growth equation thus takes the following form:

$$\Delta lnE_{t+1,t} = \alpha + \beta \Delta X_{t+1,t} + \theta \Delta F_{t+1,t} + \tau \Delta H_{t+1,t} + \mu_h + \eta_h + \Delta \epsilon_{t+1,t} \quad (10)$$

in which $\Delta lnE_{t+1,t}$ is the expenditure growth and α, β, θ *and* τ are coefficients to be estimated. $X_{t+1,t}$ is a vector of observed household characteristics that change between t and $t+1$. $F_{t+1,t}$ and $H_{t+1,t}$ are sets of variables representing the price and income shocks respectively. This specification controls for time-constant household heterogeneity thus resolving a large number of possible sources of endogeneity (e.g., ability, skill) (Wooldridge, 2012). However, it does not account for heterogeneity across households. For example, inter-household wealth difference is likely to influence household ability to grow over time as well as their capacity to withstand an exogenous shock. Therefore, we control for such inter-household heterogeneity using initial household fixed effects (μ_h) (household head's age, education, occupation, religion, land and non-land asset, highest level of female education) (Beegle et al., 2011). We also include the full set of district dummy variables to account for regional heterogeneity (η_h) such as heterogeneity in labor mobility and speed of wage adjustment.

An ordinary least square regression approach was applied to estimate Equation 10 using both per-adult and per-capita equivalent expenditure growth as dependent variables. The results

are presented in Model 1 (per-adult) and Model 2 (per-capita) of Table 4. Model 1 is the superior model in terms of adjusted R^2 value and F-statistics. The mean coefficients of the dummy variables *FS 2007* are negative and statistically significant at the 10 and 5 percent level in Models 1 and 2 respectively, implying that households that were food insecure in 2007 experienced negative expenditure growth. The mean coefficients of *FS 2008* and *FS 2009* are both negative but not statistically significant at the 10 percent level. The P-values for the coefficients of *FS 2009* in Models 1 and 2 are 0.28 and 0.12 respectively while the P-values for the coefficients of *FS 2008* are over 0.70 in both models.

INSERT TABLE 4 HERE

Although not statistically significant, the mean coefficients of *Asset Sale* are negative in both Models 1 and 2, implying a detrimental influence of productive asset depletion on expenditure growth potential. The mean coefficients of *Loan* are positive in Models 1 and 2 and significant at the five percent level in Model 2. This refutes the FAO (2009a) narrative regarding the negative effects on economic growth of indebtedness related to food insecurity.

Flood and *Non-Flood Damage, Medical Expense*, *Remittance Growth* and *Transfer 1* and *2* are indicators of income shocks. As expected, the coefficients of *Flood* and *Non-Flood Damage, Medical Expense* are negative (higher loss and damages associated with lower expenditure growth) but they are not significantly different from zero. The coefficients of *Remittance Growth and Transfer 2* are positive and statistically significant at the one percent level in both models implying households who experienced a positive growth in remittance income and those who received assistance from the government programs during the post-shock period had significantly higher expenditure growth.

Female Head is a time varying household characteristic that controls for changes in the head of the household's gender between *t* and *t+1*. The household head's gender may change due

to marriage/divorce or death of the previous household head. The mean coefficient of *Female Head* is negative and significant at the five percent level. Household head's age was significantly positively yet non-linearly correlated with expenditure growth in Model 2. Female members' higher education was significantly positively correlated with expenditure growth in both Models 1 and 2. In terms of occupation, the coefficients of dummy variables representing agricultural laborers and fisheries, livestock, and poultry farmers were positive and statistically significant in both models. The coefficients of the dummy variables agricultural farmers and salaried individuals were positive and marginally significant only in Model 1. Finally, structural heterogeneity across households was controlled by using district dummies. The principal sources of structural heterogeneity are infrastructure and the communication network, political economy-driven biases in resource allocation, as well as the speed and magnitude of wage adjustments in regional labor markets (Zohir, 2011). The baseline district was Manikganj which was the closest district from the capital (50km). All of the district dummies were negative (except for Jessore, the district bordering India) and significantly different than zero in both Models 1 and 2.

7. Discussion

Our findings reveal strong negative impacts of a food price hike on household food security in the rural areas of Bangladesh. Consistent with Ravallion's (1990) propositions, we found that the distributional impacts of the food price shock substantially varied over time and across the poor and non-poor populations. The immediate impacts (i.e., food insecurity) were borne disproportionately by the poorer (i.e., landless, assetless) and net-food-buyer households. In the longer term, as the input and commodity markets adjusted to the shock, the welfare impacts (i.e., growth in overall expenditure) were redistributed more evenly across the poor and non-poor populations and across different occupational groups.

The food security impact of the food price hike on agricultural day laborer remained inconclusive as the results varied depending on model specification. However, they were clearly among the winners when the long-term welfare consequences were considered. Self-employed farmers and share croppers were benefitted from the food price hike in the short-run as they were significantly less likely to assess themselves as food insecure. The long-term welfare consequences of the food price hike on these two occupational groups appeared to be neutral. Although they witnessed a positive post-shock expenditure growth, it was not strongly significantly different than zero. This could be due to the higher agricultural wages and the sharp rise in diesel price which resulted in a 50 percent increase in the cost of irrigation between 2005/06 and 2008/09 (BBS, 2011c). The increased production costs seemed to have overshadowed farmers' economic gains from increased food grain prices. Households engaged in the fish, poultry and livestock industry were amongst the winners both in the short- and long-run following a 47 percent increase in meat, dairy and fish prices between 2006/07 and 2009/10 (BBS, 2011d).

While the post-shock poverty rate was significantly higher than the pre-shock period, the worsening poverty could not be strongly attributed to the first-order (i.e., food shortage) or second-order (i.e., dissaving, asset sale, indebtedness) effects of the food price shock. A significant negative association between food shortage and economic growth was observed only in the case of those households that experienced hunger in 2007. Some weak evidence of similar association was observed in case of households who experienced food shortage in 2009. For households who experienced hunger in 2008, the year that witnessed the highest increase in food prices as well as the highest and most severe incidents of starvation, the negative association between economic growth and food crisis was not even remotely significant. This implies, despite the unequivocally adverse immediate effects of the food

price hike on food security, that in a majority of the cases these adversities did not manifest in longer-term destitution.

Regarding the nexus between income shock and food security, our findings varied across the nature of the shock. The food security consequences of relatively transient income shocks (e.g., natural disaster losses and unforeseen medical expenses) appeared to be quite pronounced. Households who experienced such income shocks were significantly more likely to assess themselves as food insecure. For relatively permanent income shocks (e.g., remittance income), the evidence in support of the association between food security and income shock was rather weak. The nested logit model (the superior model in terms of model fit statistics and construct validity) showed a significant positive relationship between remittance income and starvation for 2008 only. This supports the general argument that food insecurity is a likely second-order effect of an economic downturn. Apparently, the negative effects of a lower remittance growth in 2009 were somewhat diminished by the accompanying decline in food prices. Hence, the net effect on households' real income was perhaps not sufficiently profound to generate a significant adverse impact on food security in 2009.

Consistent with the propositions of the permanent income hypothesis, transitory income shocks were less relevant in explaining the inter-household variations in pre- and post-shock economic growth. Although this suggests the absence of significant inter-temporal variability in household expenditure with regards to transitory shocks, it does not necessarily indicate the absence of their association with poverty. When insurance arrangements are imperfect, households protect consumption against negative shocks by making economic decisions characterized by low risk and low return. Thus, the observed inter-temporal variability in consumption tends to understate its inherent variability (Morduch, 1994).

The welfare consequences of a relatively permanent income shock turned out to be negative. This finding is also consistent with the permanent income hypothesis which claims that consumption responds to permanent but not to transitory shocks to income. Households who experienced a negative growth in remittance income, were significantly less likely to experience a positive post-shock expenditure growth. As the economic downturn deepened and the serially dependent nature of the shock to remittance income became evident, households appeared to have adjusted their consumption by moving permanently to a lower expenditure equilibrium.

8. Conclusions and Policy Implications

Our empirical evidence, in part, supports the conventional narrative over the nexus of food price and income shocks in relation to food security and poverty. Consistent with the conclusions drawn by a majority of the simulation based studies, we conclude that the soaring food prices of 2007–2009 aggravated food insecurity among the poorer and net-food-buyer households in the rural areas of Bangladesh. The subsequent transitory income shocks arising from covariate and idiosyncratic events during the same period contributed towards worsening food insecurity. However, we did not find any evidence to suggest that such shocks persist far into the future by forcing households into longer-term poverty or destitution. The adverse impacts of food price and (transitory) income shocks appeared to have faded over time leaving no profound impacts on households' economic welfare in most cases.

Like the country level studies by Headey (2013) and Verpoorten et al. (2013), our household level study suggests that the food security and welfare consequences of food price and income shocks are highly context specific. Even in the same country, regional (structural)

differences (e.g., speed of labor and commodity market adjustments, infrastructure and domestic policy responses) may significantly dictate the nature and extent of post-shock economic growth. Proximity to the national capital played an important role in explaining the variation of household expenditure growth in our dataset. A closer proximity to the capital offered higher economic opportunities and thus greater off-farm labor mobility which in turn allowed rapid on-farm wage adjustment. Households living in the district bordering India (Jessore) also appeared to have benefited from the spillover effects of economic growth of the neighboring nation through cross-border trade and labor mobility.

This inter-regional heterogeneity in growth and poverty dynamics need to be accounted for in the design of the national response strategies to external shocks. Government interventions (e.g., fiscal transfer, food distribution programs) need to target priority areas that are characterized by lower economic opportunities and slower labor mobility. Fiscal policies that facilitate faster on- and off-farm wage adjustment (e.g., off-farm employment generation programs, increased access to agricultural credit) should be at the core of the response frameworks dealing with external economic shocks.

In addition to the price shock, agricultural seasonality emerged as a strong predictor of the incidences of starvation in rural villages of Bangladesh. Thus, even in the absence of any price shock, rural households were at significant risk of experiencing hunger, particularly during the dry season lean period. This emphasizes the need for government interventions aimed at widening and deepening the social safety net programs in rural areas to curb seasonal food insecurity.

The nexus between transitory income shock and food security highlights the absence of an effective risk sharing mechanism in the rural villages of Bangladesh. Despite Bangladesh's overwhelming success in microcredit over the past decades, the availability and penetration of risk insurance has been remarkably low, particularly in the rural areas. Even the insurable (idiosyncratic) risks are managed via informal social institutions through non-binding, reciprocity based contracts (Akter, 2012). These arrangements are evidently failing to smooth out consumption across good and bad years. Thus, efforts to accelerate the development of a formal insurance market need to be intensified.

Access to credit appeared to have prevented some households from moving into a lower expenditure equilibrium at times of crises. However, access to and the availability of institutionalized credit does not seem to be widespread. The most common sources of credit are informal institutional. Increased access and availability of soft credits (with low interest rates) should be targeted towards net-food-buying, non-agricultural households in areas where off-farm wage employment opportunities are limited.

Our study uses an innovative econometric approach to model qualitative food security data and presents new empirical evidence in relation to the validity of qualitative indicators as a measure of food security. The estimated nested logit model results present a construct validity test by examining the correlation of a self-assessed indicator with theoretically expected explanatory variables. The results demonstrate strong evidence of construct validity, as the coefficients of the explanatory variables displayed (in most cases) the theoretically expected signs and statistically significant values. Further, unlike the previous studies, we did not find any evidence of an upward bias in our self-assessed food security indicator, as poorer households were significantly more likely to assess themselves as food insecure. These

findings demonstrate that subjective indicators can be a valid measure of food (in)security, at least in an intra-country assessment context.

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Figure 1(a). Monthly retail price of coarse rice in Bangladesh and FAO Cereal Price Index during 2007–2009

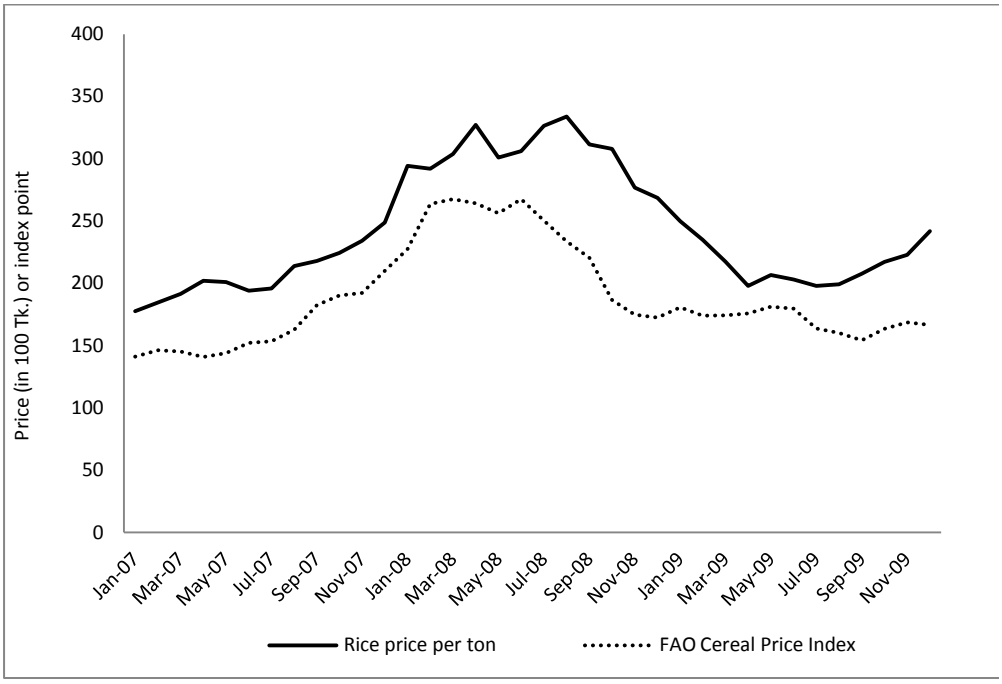
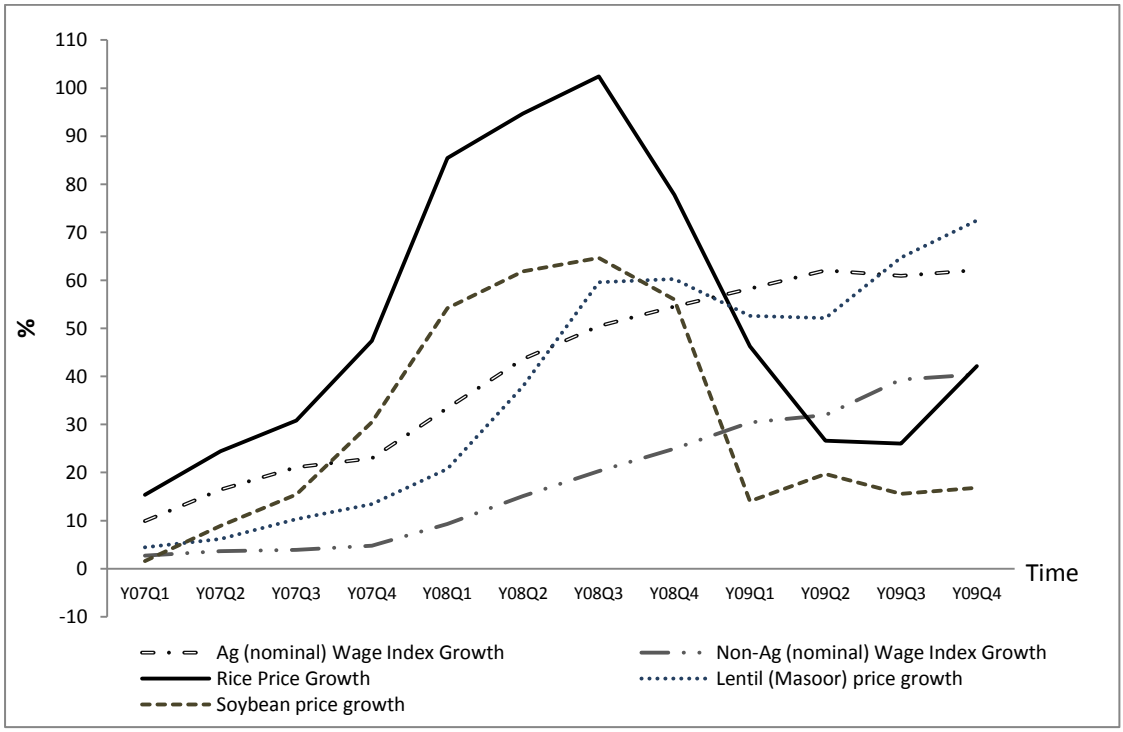


Figure 1(b). Wage and food price growth in Bangladesh during 2007–2009



Notes:

In Figure 1(b), Y stands for year and Q stands for quarter. Baseline is Y06Q4.

Sources:

1. Department of Agriculture Marketing of the Ministry of Agriculture, Government of Bangladesh (2013)
2. BBS (2011d)
3. FAO (2013)

Figure 2(a). Foreign wage earners' remittance and skilled labor migration growth in Bangladesh during 2005/6–2009/10

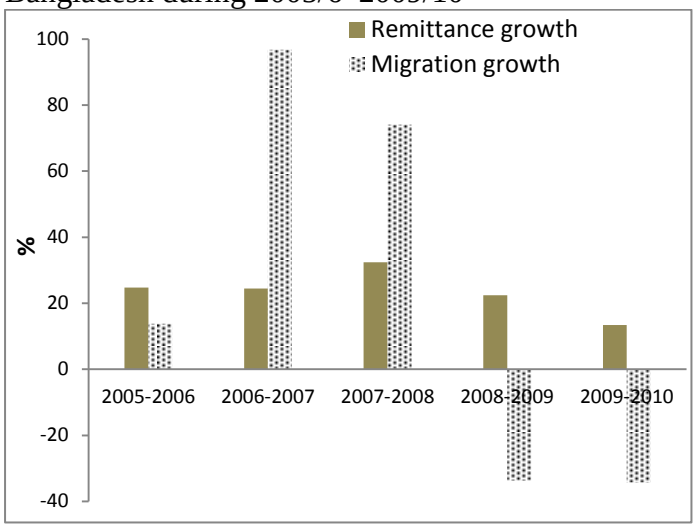


Figure 2(b). Export and import growth in Bangladesh during 2005/6–2009/10

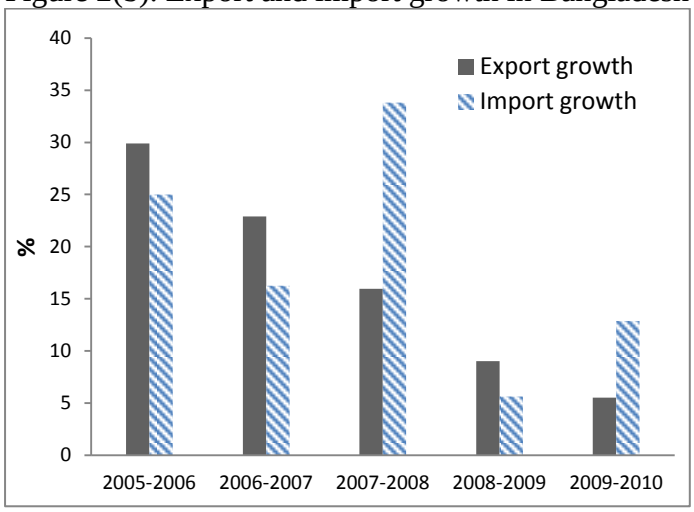
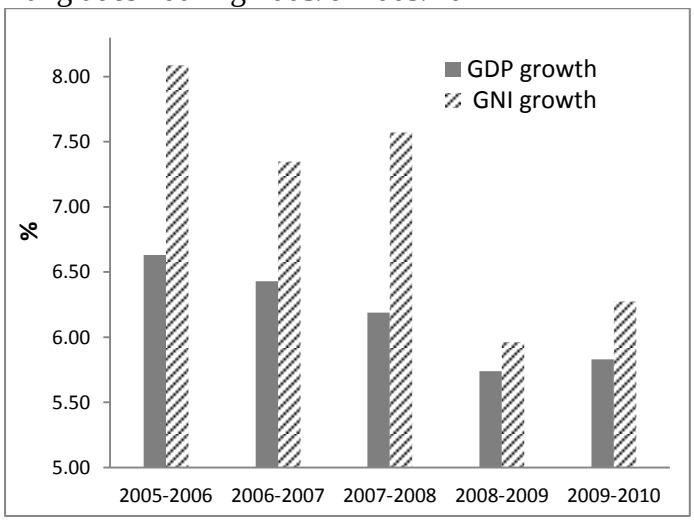
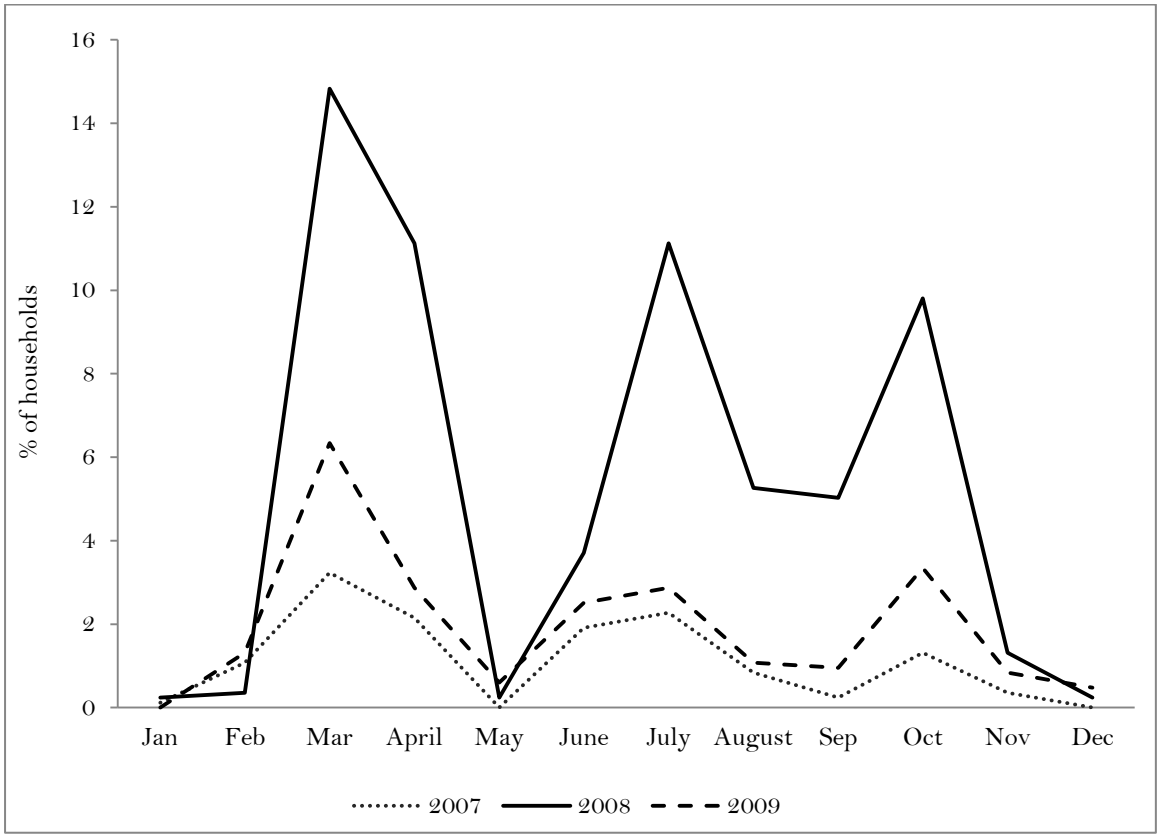


Figure 2(c). Gross domestic product (GDP) and Gross national income (GNI) growth in Bangladesh during 2005/6–2009/10



Source: Bangladesh Bank (2013)

Figure 3 Incidences of the worst food crisis during 2007–2009



Source:
Household Income and Expenditure Survey data 2009/10 (IFPRI, 2012)

Figure 4. Descriptors for the three-level nested logit tree

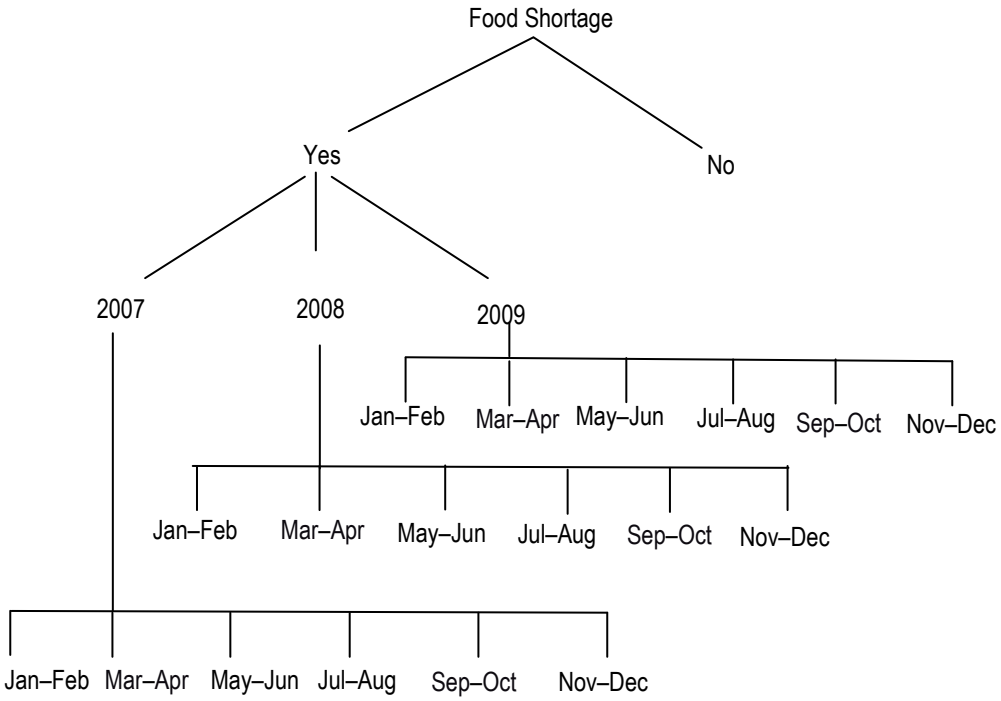
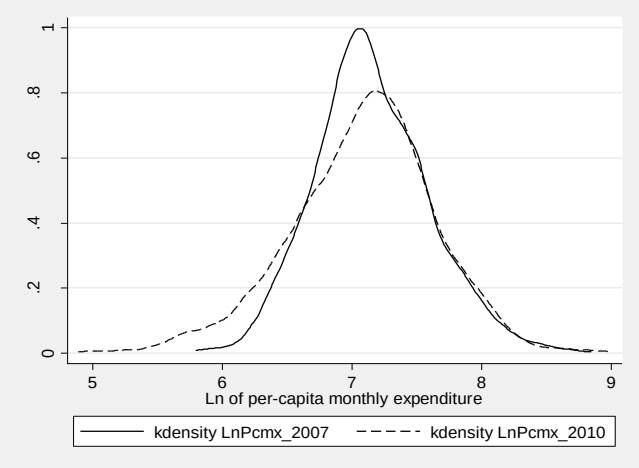
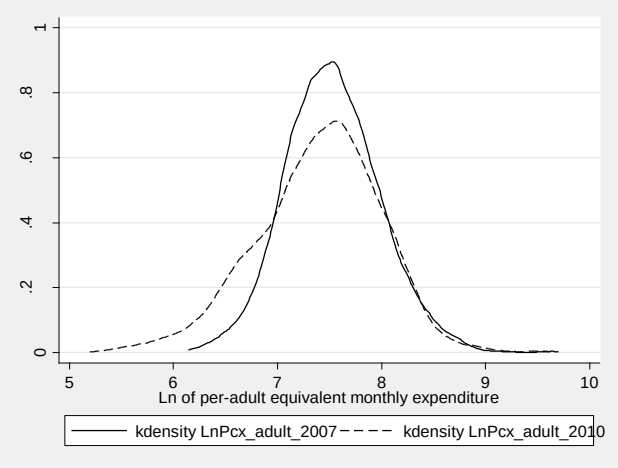


Figure 5. Kernel density estimation of (a) per-capita and (b) per-adult (15+) equivalent monthly expenditures: 2006/07 and 2009/10





Notes:
LnPcmx_2007= Natural log of per capita monthly expenditure in 2007
LnPcmx_2010= Natural log of per capita monthly expenditure in 2010
LnPcmx_adult_2007= Natural log of per adult equivalent monthly expenditure in 2007
LnPcmx_adult_2010= Natural log of per adult equivalent monthly expenditure in 2010

Source:
Household Income and Expenditure Survey data 2006/07 and 2009/10 (IFPRI, 2012)

Table 1. Linear regression results of rice price on FAO Cereal Price Index and time (Dependent variable=rice price in Taka per kg)

Explanatory variables	Variable description	Coefficient (SE)
Constant		9.41*** (2.71)
Y07Q1*FCPI	Quarter I & Year 2007=1 interacted with FAO Cereal Price Index	0.06*** (0.019)
Y07Q2*FCPI	Quarter II & Year 2007=1 interacted with FAO Cereal Price Index	0.07*** (0.019)
Y07Q3*FCPI	Quarter III & Year 2007=1 interacted with FAO Cereal Price Index	0.07*** (0.016)
Y07Q4*FCPI	Quarter IV & Year 2007=1 interacted with FAO Cereal Price Index	0.07*** (0.014)
Y08Q1*FCPI	Quarter I & Year 2008=1 interacted with FAO Cereal Price Index	0.008 (0.015)
Y08Q2*FCPI	Quarter II & Year 2008=1 interacted with FAO Cereal Price Index	0.12** (0.056)
Y08Q3*FCPI	Quarter III & Year 2008=1 interacted with FAO Cereal Price Index	0.05** (0.022)
Y08Q4*FCPI	Quarter IV & Year 2008=1 interacted with FAO Cereal Price Index	0.27*** (0.043)
Y09Q1*FCPI	Quarter I & Year 2009=1 interacted with FAO Cereal Price Index	0.08*** (0.015)
Y09Q2*FCPI	Quarter II & Year 2009=1 interacted with FAO Cereal Price Index	0.06*** (0.015)
Y09Q3*FCPI	Quarter III & Year 2009=1 interacted with FAO Cereal Price Index	0.07*** (0.017)
Y09Q4*FCPI	Quarter IV & Year 2009=1 interacted with FAO Cereal Price Index	0.08*** (0.016)
Y08Q1	Quarter I & Year 2008=1, otherwise=0	18.39*** (4.65)
Y08Q2	Quarter II & Year 2008=1, otherwise=0	–8.40 (14.97)
Y08Q3	Quarter III & Year 2008=1, otherwise=0	11.78** (5.87)
Y08Q4	Quarter IV & Year 2008=1, otherwise=0	–28.38*** (8.16)
Adjusted R^2		0.90
F		230 (df=16, p<0.001)
N		36

Note:
*, ** and *** denotes statistical significance at the 10%, 5% and 1% level, respectively.

Table 2. Determinants of self-assessed food security: Nested and multinomial logit regression results

Explanatory variables		Mean Coefficient (Standard Errors)	
Names	Descriptions	Model 1: Nested Logit	Model 2: Multinomial Logit
Level 1			
Price	Bimonthly average price of per kg rice from Jan–Feb 2007 to Nov–Dec 2009 (in Taka)	0.16*** (0.03)	0.07*** (0.007)
Lean 1	Dry season lean period (March–April=1, Otherwise=0)	1.40*** (0.08)	0.08 (0.06)
Lean 2	Wet season lean period (Sep–Oct=1, Otherwise=0)	0.73*** (0.10)	–0.62*** (0.08)
Price*Farmer	Rice price interacted with self-employed farmer	–0.03** (0.01)	–0.02** (0.01)
Price*ShareCrop	Rice price interacted with Share cropper	–0.04** (0.02)	2e-03 (0.02)
Price*AgLaborer	Rice price interacted with agricultural day laborer	–0.02** (0.01)	0.05*** (0.01)
Price*NAgLaborer	Rice price interacted with non-agricultural day laborer	–5e-03 (8e-03)	0.014 (0.02)
Price*Fish, Poultry and Livestock	Rice price interacted with fish, poultry and livestock farmers	–0.023** (0.01)	–0.05*** (0.02)
Price*Salaried	Rice price interacted with salaried individuals	0.02* (0.01)	–6e-03 (0.01)
Level 2			
Rem 2007	Natural log of remittance income in 2007 (in Taka)	–0.03 (0.04)	–0.26*** (0.03)
Rem 2008	Natural log of remittance income in 2008 (in Taka)	–0.05** (0.02)	–0.13*** (0.015)
Rem 2009	Natural log of remittance income in 2009 (in Taka)	–0.04 (0.02)	–0.19*** (0.02)
Loss & Dam 2007	Natural log of loss and damage incurred due to negative shocks in 2007 (in Taka)	0.06 (0.04)	–0.09** (0.04)
Loss & Dam 2008	Natural log of loss and damage incurred due to negative shocks in 2008 (in Taka)	0.05** (0.02)	0.05*** (0.015)
Loss & Dam 2009	Natural log of loss and damage incurred due to negative shocks in 2009 (in Taka)	0.04* (0.02)	–0.06*** (0.02)
Positive 2007	Household experienced positive	–0.53	–1.90*

	event in 2007 (Yes=1, Otherwise=0)	(1.10)	(1.03)
Positive 2008	Household experienced positive event in 2008 (Yes=1, Otherwise=0)	0.08 (0.32)	0.26 (0.27)
Positive 2009	Household experienced positive event in 2009 (Yes=1, Otherwise=0)	0.12 (0.33)	–0.60* (0.30)
Level 3(all variables measured at the baseline: 2006/07)			
Asset	Value of per-capita non-land asset (in '000 Taka)	–0.05*** (7e-03)	–0.04*** (6e-3)
Expenditure	Per-capita household expenditure (in '000 Taka)	–0.07*** (0.02)	–0.012 (0.012)
Land	Size of cultivable land (in hectare)	–2e-03*** (6e-04)	–1.5e-3** (6e-04)
Religion	Muslim=1, Otherwise=0	0.01 (0.20)	0.23 (0.20)
Female Head	Female headed household (Yes=1, Otherwise=0)	–0.09 (0.18)	–0.17 (0.16)
Net Buyer	Proportion of food purchased from the market relative to home-grown production	0.66*** (0.13)	0.80*** (0.08)
Division 1	Barishal=1, Otherwise=0[b]	–1.24*** (0.36)	–1.30*** (0.34)
Division 2	Chittagong=1, Otherwise=0[b]	–2.00*** (0.30)	–1.75*** (0.27)
Division 3	Khulna=1, Otherwise=0[b]	–0.43*** (0.13)	–0.09 (0.11)
IV parameters	Wald test for IV parameter=1		
δ_9	Z=1.58 (p=0.11)	2.30 (0.88)	–
λ_{2007}	Z=0.54 (p=0.60)	1.47 (0.87)	–
λ_{2008}	Z=0.57 (p=0.57)	1.40 (0.70)	–
λ_{2009}	Z=0.62 (p=0.53)	1.53 (0.85)	–
Model fit statistics			
Number of iterations		500	–
Log likelihood function		–3050	–8637
McFadden Pseudo R-squared		0.16	–
Observations (N)		1810	1810
AIC information criteria		6163	17329
AIC/N		3.40	9.57

Notes:
*, ** and *** denotes statistical significance at the 10%, 5% and 1% level, respectively.
[a] Baseline category = Traders
[b] Baseline category = Inland divisions (Dhaka and Rajshahi)

Table 3. Poverty dynamics between 2007–2010 (% of households below the upper poverty line)

	Poor in 2007	Out of Poverty in 2010	Moved to poverty in 2010	Total poor in 2010	Growth in poverty	Z statistics (P value)
Full Sample (N=1815)	6.20	3.30	18.30	21.00	14.80	–
No Food shortage (N=1000)	3.60	2.30	16.40	17.60	14.00	0.76[a] (*p*=0.45)
Experienced food shortage in 2007 (N=107)	8.40	2.80	23.40	29.00	20.60	1.51[b] (*p*=0.13)
Experienced food shortage in 2008 (N=515)	11.00	5.40	22.30	28.00	17.00	1.18[c] (*p*=0.24)
Experienced food shortage in 2009 (N=191)	6.30	3.10	13.10	16.20	10.00	1.41[d] (*p*=0.16)

Notes:
[a]Z statistics of mean difference test between 'no food insecurity' versus 'food insecure during 2007–2009'.
[b]Z statistics of mean difference test between 'no food insecurity' versus 'food insecure during 2007'.
[c]Z statistics of mean difference test between 'no food insecurity' versus 'food insecure during 2008'.
[d]Z statistics of mean difference test between 'no food insecurity' versus 'food insecure during 2009'.

Source:
Household Income and Expenditure Survey data 2006/07 and 2009/10 (IFPRI, 2012)

1 Table 4. Determinants of expenditure growth between 2007 and 2010

2

Variable names	Variable description	Model 1[a] mean coefficient	Model 2[b] (standard error)
Indicators of Food Price Shock			
FS 2007	Households experienced acute food shortage in 2007 (Yes=1, Otherwise=0)[c]	–0.11*	–0.11**
		(0.06)	(0.06)
FS 2008	Households experienced acute food shortage in 2008 (Yes=1, Otherwise=0) [c]	–0.01	–0.01
		(0.04)	(0.03)
FS 2009	Households experienced acute food shortage in 2009 (Yes=1, Otherwise=0) [c]	–0.05	–0.07
		(0.05)	(0.05)
Asset	Sold asset to cope with food crisis (Yes=1, Otherwise=0)	–0.06	–0.04
		(0.05)	(0.04)
Loan	Borrowed money to cope with food crisis (Yes=1, Otherwise=0)	0.05	0.08**
		(0.03)	(0.03)
Savings	Depleted savings to cope with food crisis (Yes=1, Otherwise=0)	0.02	2e-03
		(0.03)	(0.03)
Indicators of Income Shock			
Rem Growth	Growth in remittance income between 2006/07 and 2009/10 (in ln)	0.015***	0.014***
		(0.004)	(0.004)
Transfer 1	Households did not receive transfer income in 2006/07 but received it in 2009/10 (Yes=1, Otherwise=0)[d]	0.17***	0.15***
		(0.06)	(0.05)
Transfer 2	Households received transfer income in 2006/07 but did not receive it in 2009/10 (Yes=1, Otherwise=0)[d]	0.03	0.03
		(0.04)	(0.03)
Flood Damage	Riverine flood and storm surge related damage and losses incurred between 2006/07 and 2009/10 (in ‘000 Taka)	–0.01	–6e-03
		(0.01)	(9e-03)
Non-flood Damage	Damage and losses incurred due to reasons other than flooding between 2006/07 and 2009/10 (in ‘000 Taka)	–2e-03	–2e-03
		(4e-03)	(4e-03)
Medical Expense	Unforeseen medical expenses incurred between 2006/07 and 2009/10 (in ‘000 Taka)	–3e-04	–4e-04
		(4e-04)	(4e-04)

Time-varying Heterogeneity			
Female Head	Household head is female at *t*=1 but was male at *t*=0 (Yes=1, Otherwise=0)	–0.11**	–0.11**
		(0.05)	(0.04)
Fixed Heterogeneity (measured at the baseline: 2006/07)			
Age	Household head's age (in years)	6e-03	0.02***
		(4e-03)	(4e-03)
Age square		–6e-05	–2e-04***
		(5e-05)	(4e-05)
Education	Head of household's education (in years)	6e-04	1.5e-03
		(4e-03)	(4e-03)
Female Education	Highest education of female household member (in years)	8e-03*	7e-03*
		(4e-03)	(4e-03)
Religion	Religion (Muslim=1, Otherwise=0)	4e-04	0.034
		(0.05)	(0.05)
Land	Size of cultivable land (in hectare)	–1.5e-04	–8.8e-05
		(1.2e-04)	(1.7e-03)
Asset	Value of non-land asset (in '000 Taka)	–1.1e-04	–8e-05
		(2e-04)	(1.1e-04)
Net Buyer	Proportion of food purchased from the market relative to home-grown production	–0.03	–0.03
		(0.03)	(0.03)
Farmer	Self-employed farmer=1, Otherwise=0[d]	0.06*	0.02
		(0.03)	(0.03)
Share Cropper	Share cropper =1, Otherwise=0[d]	0.04	0.02
		(0.06)	(0.05)
Ag Day Laborer	Agricultural day laborer =1, Otherwise=0[d]	0.10***	0.08**
		(0.04)	(0.04)
Fish, Poultry and Livestock	Fish, poultry and livestock farmer=1, Otherwise=0 [d]	0.16***	0.16***
		(0.05)	(0.04)
Non-ag Day Laborer	Non-agricultural day laborer=1, Otherwise=0[d]	–0.03	–0.04
		(0.05)	(0.04)
Salaried Employment	Salaried employment (Yes=1, Otherwise=0)[d]	0.07*	0.05
		(0.04)	(0.04)

Fixed structural heterogeneity			
District 1	Pakundia =1, Otherwise=0[e]	–0.26***	–0.18***
		(0.06)	(0.05)
District 2	Sherpur =1, Otherwise=0[e]	–0.58***	–0.46***
		(0.07)	(0.07)
District 3	Madhupur =1, Otherwise=0[e]	–0.58***	–0.48***
		(0.06)	(0.07)
District 4	Gaffargaon =1, Otherwise=0[e]	–0.45***	–0.36***
		(0.05)	(0.05)
District 5	Jessore =1, Otherwise=0[e]	0.20***	0.14***
		(0.04)	(0.04)
District 6	Nayagati =1, Otherwise=0[e]	–0.38***	–0.28***
		(0.07)	(0.07)
District 7	Agoiljhara =1, Otherwise=0[e]	–0.31***	–0.21**
		(0.09)	(0.08)
District 8	Hazigonj =1, Otherwise=0[e]	–0.37***	–0.18**
		(0.08)	(0.08)
District 9	Chakaria =1, Otherwise=0[e]	–0.32***	–0.20***
		(0.08)	(0.07)
District 10	Nilphamari=1, Otherwise=0[e]	–0.50***	–0.41***
		(0.07)	(0.07)
District 11	(Mohadevpur=1, Otherwise=0)[e]	–0.40***	–0.33***
		(0.07)	(0.07)
Constant		–0.20*	–0.36***
		(0.11)	(0.10)
Model fit statistics			
R-squared		0.24	0.20
Adjusted R-squared		0.22	0.18
Observations		1810	1810
F(*df*=38, 1771)		15	11
		P<0.0001	*P*<0.0001

1

Notes: *, ** and *** denotes statistical significance at the 10%, 5% and 1% level, respectively.
[a] Dependent variable = per adult equivalent household expenditure.
[b] Dependent variable = per capita household expenditure.
[c] Baseline category = no food crisis.
[d] Baseline category = Households' status in terms of receiving transfer income remained unchanged between 2006/07 and 2009/10 Traders.
[e] Baseline category = Manikganj (the closest district from the capital Dhaka)

Appendix A. Sample distribution across districts and survey rounds, Bangladesh, 2006/07 and 2009/10.

	Districts	Number of households	
		2006/07	2009/10
FFE/CFE Study[a]	Nilphamari	70	82
	Naogaon	66	67
	Sherpur	71	73
	Tangail	67	65
	Narail	64	68
	Barisal	58	56
	Chandpur	58	56
	Cox's Bazar	58	58
MCG Study[b]	Manikganj	409	438
	Mymensingh	166	187
	Kishoreganj	214	246
	Jessore	448	458
	Total 2006/07	1748	1853
	Dropped out	-71	
	Split	139	
	Total 2009/10		1816

[a]Impact evaluation study on 'food/cash for education'.
[b]Impact evaluation study on 'agricultural technology adoption'.

Source: Household income and expenditure survey 2006/07 and 2009/10, International Food Policy Research Institute (IFPRI), 2012.

Appendix B. Self-assessed food security module used during the 2009/10 survey round

Section xx. Consumption patterns since the last survey round
Administer this to the female respondent
Respondent ID:____

1. Are there any months in a **typical year** when the household runs out of food AND money to buy food? *[WE ARE INTERESTED IN SEASONAL PROBLEMS, NOT EXCEPTIONAL YEARS, THE ISSUE IS TO KNOW WHEN STOCKS TYPICALLY GET DEPLETED.]* **Code (a)** *IF YES, list all of the months in a typical year it usually happens. If NO, go to next question]*	Month [___] Month [___] Month [___] Month [___] Month [___] Month [___]		
2. How many months since 2007 did you have problems satisfying the food needs of the household?			
3. Did this happen in the last 12 months**? Code (a***) IF YES*, list the months during which it happened?	Month [___] Month [___] Month [___] Month [___] Month [___] Month [___]		
If No to 1, 2 AND 3, skip to next section			
4. In each of the following years, which month was the shortage of food most acute for your household? (*Record month as 1-12. If household did not experience any food shortage, skip to 7.)*	*2007* Month [___]	*2008* Month [___]	*2009* Month [___]
5. Of the three months mentioned above, which was the worst? *(Record month and year)*			
Questions 6-11d refer to the month and year identified as the worst in Question 4			
6. Compared to your usual diet, did you eat foods that you ordinarily would not eat, "less preferred foods"? **(Code b)**			
7. Compared to your usual diet, did you cut back quantities served per meal to adult males? **(Code b)**			
8. Compared to your usual diet, did you cut back quantities served per meal to adult females? **(Code b)**			

9. Compared to your usual diet, did you cut back quantities served per meal to boys **(Code b)**	
10. Compared to your usual diet, did you cut back quantities served per meal to girls **(Code b)**	
11a. During the worst month, how many times a day did adult males in your household eat?	
11b. During the worst month, how many times a day did adult females in your household eat?	
11c. During the worst month, how many times a day did boys or male children in your household eat?	
11d. During the worst month, how many times a day did girls or female children in your household eat?	
12a. During a good month, how many times a day did male adults in your household eat?	
12b. During a good month, how many times a day did female adults in your household eat?	
12c. During a good month, how many times a day did boys or male children in your household eat?	
12d. During a good month, how many times a day did girls or female children in your household eat?	

Source: Household income and expenditure survey data 2009/10 by the International Food Policy Research Institute (IFPRI, 2012).

Appendix C. Price elasticity[a] of food insecurity during 2007–2009.

Months, Year	Price elasticity NL Model	Price elasticity MNL Model
Jan–Feb, 2007	2.20	1.20
Mar–Apr, 2007	2.08	1.30
May–June, 2007	2.38	1.30
Jul–Aug, 2007	2.48	1.35
Sep–Oct, 2007	2.51	1.50
Nov–Dec, 2007	2.88	1.60
Jan–Feb, 2008	3.60	1.89
Mar–Apr, 2008	3.28	1.99
May–June, 2008	3.66	1.92
Jul–Aug, 2008	3.98	2.08
Sep–Oct, 2008	3.58	2.05
Nov–Dec, 2008	3.41	1.80
Jan–Feb, 2009	2.99	1.64
Mar–Apr, 2009	2.30	1.40
May–June, 2009	2.50	1.36
Jul–Aug, 2009	2.46	1.33
Sep–Oct, 2009	2.51	1.45
Nov–Dec, 2009	2.82	1.54

[a] Price elasticity of food insecurity is the change in the probability of experiencing food shortage for 1% change in rice price, holding other factors constant.

Appendix D. Poverty line expenditures and food and non-food CPI.

	Year 2007	Year 2010
Upper Poverty Lines Expenditures for Rural Areas		
Food poverty Line	Tk 636 (US$9)	Tk 953 (US$14)
Non-Food allowance	Tk 323 (US$5)	Tk 358 (US$5)
Upper poverty line	Tk 959 (US$14)	Tk 1311 (US$19)
Consumer Price Index, Rural (Base : 1995-96=100)		
General	177	223
Food, beverage and tobacco	182	236
Non-food	169	202

US$ 1 = Tk 69.

Source: Household income and expenditure survey (BBS, 2011a).

Appendix E. Per-adult (aged 15 years and above) equivalent monthly expenditures in 2007 and 2010.

	Mean 2007 (Taka (US$))	Mean 2010 [deflated] (Taka (US$))	Mean difference[a] (Taka (US$))
Full Sample (N=1810)			
Total expenditure	2077 (30)	1928 (28)	–149 (–2.15)***
Food expenditure	1488 (21.6)	1350 (19.5)	–138 (–2.00)***
Non-food expenditure	589 (8.54)	577 (8.4)	–12 (0.15)
Households with No Food Shortage (N=1000)			
Total expenditure	2272 (34.35)	2098 (30.40)	–174 (–2.50)***
Food expenditure	1590 (23.03)	1443 (21.00)	–147 (2.13)***
Non-food expenditure	682 (9.87)	654 (9.50)	–28 (0.40)
Households Experienced Food Shortage in 2007 (N=107)			
Total expenditure	1814 (26.30)	1596 (23.13)	–218 (–3.16)*
Food expenditure	1330 (19.30)	1152 (16.70)	–178 (–2.58)*
Non-food expenditure	484 (7)	444 (6.43)	–40 (–0.58)
Households Experienced Food Shortage in 2008 (N=515)			
Total expenditure	1786 (25.88)	1679 (24.33)	–107 (1.55)**
Food expenditure	1328 (19.25)	1221 (17.70)	–107 (–1.55)***
Non-food expenditure	457 (6.60)	458 (6.64)	1 (0.01)
Households Experienced Food Shortage in 2009 (N=191)			
Total expenditure	2004 (29)	1886 (27.33)	–118 (–1.71)
Food expenditure	1481 (21.5)	1325 (19.20)	–156 (–2.26)**
Non-food expenditure	524 (7.60)	561 (8.13)	37 (0.54)

Paired *t*-test is used to determine the mean price difference between two periods and tests whether the average differs from 0.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

Source: Household income and expenditure survey 2006/07 and 2009/10 (IFPRI, 2012).